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THE MORPHOLOGY AND LIFE HISTORY OF A NEW
TREMATODE PARASITE, *LISSORCHIS FAIRPORTI*
NOV. GEN., ET NOV. SPEC. FROM THE
BUFFALO FISH, *ICTIOBUS* *

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During the summer of 1917, while working as an investigator for the United States Bureau of Fisheries at the Fairport Biological Station, my attention was directed to certain ponds for experimental fish culture where young buffalo fry had suddenly begun to die in large numbers. The problem was assigned to me for investigation, and I thank the Bureau for its assistance and for the opportunity afforded.

These fry hatched from artificially fertilized eggs on about May 20, and were divided into three batches. One lot of 36,000 was placed in pond 16 *B*, another of 6,500 in pond 3 *F*, and the third of 2,500 in pond 2 *F*. It was in these latter two ponds that the death rate was so high while in 16 *B* no unusual death rate was noted. Unfortunately, the records on pond 2 *F* are incomplete, but not so many died there as in pond 3 *F*. The death record for 3 *F* is as follows:

July 2.....	331	were found dead
July 3.....	329	were found dead
July 6.....	288	were found dead
Total.....	948	dead in four days' time
A few others died afterwards.		

This is not the first time that large numbers of buffalo fish have been lost in the experimental ponds at Fairport. On May 24, 1916, pond 7 *D* was drawn off and there were found only 1,113 fingerlings of the 19,433 fry which had been put into this pond the previous summer. Only 145 fish had been removed for experimental purposes, so that 18,175 were unaccounted for. It should be noted here that buffalo fish in this pond were infected with the same trematode as found in the dead fry from ponds 2 and 3 *F*, and which will be discussed in this paper.

There was nothing unusual about the conditions of these ponds, and all the ponds got their water supply from the same source. There seemed to be plenty of food and the fish were making good growth. There was no blanket of algae in pond 2 *F*, and this might have

* Contribution from the Laboratory of the United States Bureau of Fisheries, Fairport, Iowa.

accounted in some measure for the fact that there were fewer chironomid larvae in this pond than in 3 *F* where there was a small blanket of mixed algae.

The stomachs of eight fish averaging 4.6 cm. in length were examined and it was found that only two had eaten chironomids, and in these it formed only 2% of the food. Of the six fish averaging 5 cm. in length taken from pond 3 *F* four had eaten chironomids, and in these the larvae made up from 1% to 85% of the total food. Other plankton forms were found in the stomachs of all the fish.

The fish from both ponds presented no unusual appearance when found dead, and no unusual growth of fungus was noted. They were not badly bruised and their gills were comparatively free from silt; no ectotrematodes and but few myxosporidian parasites were found. Upon systematic examination of the fish for animal parasites there was found only one species and this proved to be a new trematode. It was always present in the dead fish and ranged in numbers from one to six or seven per host. These trematodes were immature, very active, and in proportion to the small size of the intestine of the fry occupied a considerable portion of its lumen. Their intestinal ceca were always gorged with food, and the evidence seems strongly in favor of the conclusion that these parasites were in some way responsible for the death of the fry, all the more so as the fry in other ponds were uninfected and did not die in noticeably large numbers. About 50 per cent. of the fry which were living in pond 3 *F* were infected, while only 20 per cent. in pond 2 *F* were infected. These figures were obtained after the fish had stopped dying.

It seems well here to emphasize a point which is often misunderstood. Many times parasites are of themselves not injurious to their hosts, yet their ultimate effect is detrimental. Often typical cases of icterus are produced by the mechanical stoppage of the gall duct by worms which otherwise would not seriously inconvenience the victim. It is not unlikely that in this case the buffalo fish were weakened to such an extent by the parasites that they died from some cause which would otherwise not have affected them. Along these lines of research there is much to be done in the field of parasitology and its importance demands the attention of investigators.

An examination of one and two year old buffalo fish from the experimental ponds showed that they harbored the same parasite in their intestines, and that the percentage of infection was about fifty. Here the adult and immature forms were found upon which, together with material from the fry, the following description is based. It is interesting in the light of what is to follow that in over two dozen buffalo fish taken from the river in the neighborhood of Fairport, none were found infected with this parasite.

The following table shows the degree of infection of one and two year old buffalo fish from ponds 5 and 7 D.

	<i>Ictiobus cyprinella</i>	<i>Ictiobus bubalus</i>
Number examined	13	8
Number infected	6	4
Number not infected.....	7	4
Percentage of infection.....	45	50
Infection in both species, 47%		

A careful study of this parasite has justified the creation of a new genus of which it is the type species. I propose to call the genus *Lissorchis*, and present it with the following description:

MORPHOLOGY OF LISSORCHIS NOV. GEN.

Lissorchis. Body flattened, elongate, tapering posteriorly and of moderate size. Cuticula covered with small spines; fleshy spines around suckers. Acetabulum powerful and as large or larger than oral sucker which is also well developed. Prepharynx and esophagus much reduced; intestinal crura not reaching posterior end. Excretory system Y-shaped, branching anterior to testes. Genital pore marginal and sinistral, situated below middle of acetabulum. Ovary mesial and lobed, no seminal receptacle; Laurer's canal present. Uterus coiled and extending from beyond genital pore to posterior tip of body, filled with small thin-shelled eggs. Testes ovoid, large, mesial and unlobed, lying in line with ovary and posterior to it. Very large seminal vesicle and well developed cirrus anterior to ectal end of uterus. Vitellaria extending on either side from posterior side of acetabulum to half way between posterior tip and acetabulum. Vitellarial sac present and Mehlis' gland large. Habitat: Intestine of fresh-water fishes. Type species: *Lissorchis fairporti*.

It becomes evident that this genus can not be embraced by any of the previously described subfamilies, and so it is here placed as the type genus of the new subfamily Lissorchiinae, the characters of which, must at present, be taken from the genus. If Lühe (1909) is followed this subfamily would be placed under the family Distomata, but according to more recent work these subfamilies have, for the most part, been elevated to the rank of families. If this tendency is followed, it seems necessary to create a new family or to modify the family Plagi-orchidae so as to contain it, but an ultimate decision of this point will not be attempted in the present paper.

LISSORCHIS FAIRPORTI NOV. SPEC.

Altho this worm is very active its activity is confined to the anterior portion of the body so that the part posterior to the acetabulum is practically motionless.

Well extended worms are in the form of an elongated oval (Fig. 1) with the posterior end pointed and the region of the acetabulum widest. The adult mature worms are from 2 mm. to 3 mm. long, altho in life they are capable of extending themselves to 5 mm. in some cases. The average thickness of the worms in the region of the acetabulum is 0.61 mm. The ratio of the anterior to the posterior portion of the body is 1:1.7, altho this is subject to some variation depending upon the degree of extension of the anterior portion.

The cuticula (Fig. 20) of these worms is about 7μ thick and is covered in all regions of the body with spines which do not protrude their entire length thru the cuticula. These spines are most prominent at the posterior end. They are 20μ long, sharply pointed, and have a proximal thickening. Muscular activity of the body serves to extrude them partly.

The oral sucker (Figs. 1, 12, and 13) is large and slightly oval, being 0.38 mm. by 0.41 mm. It is surrounded on its outer margin by small fleshy spines, which occur in two or three rows. In ratio to the length of the pharynx this sucker is 7:5, and in ratio to the ventral sucker it is 7:9. The ventral sucker (Figs. 1, 12, 15) is powerful and round, being about 0.55 mm. in diameter. It, too, is surrounded by several rows of fleshy spines. The muscular pharynx (Fig. 14) leads immediately into the intestinal crura which are generally gorged with food and extend to near the posterior tip of the body, but never entirely so, the uterus lying in the intervening space.

The excretory system (Figs. 2, 19) was studied in living specimens. The pore is situated in the middle of the tip, and from it there leads forwards a rather large median duct, which does not give off branches but is capable of distention. This median trunk divides on the dorsal side of the worm and just forward of the anterior testis. At the base of the two divisions there are slight enlargements, which assume the appearance of a bicornuate bladder during certain stages of the excretory process. Each main lateral branch shortly gives off a branch which passes posteriad and obliquely to near the lateral margin of the worm and then branches into two main stems, one passing up anteriad and the other posteriad; these in turn break up into numerous branches with flame cells at their terminals. The rest of the two lateral branches pass anteriad on their respective sides, giving off branches en route, finally making a loop near the base of the oral sucker, they pass posteriad lateral to the ascending trunks and break up in numerous branches. This arrangement is characteristic and practically no variation of any note was recorded.

The ovary (Fig. 17) lies in a median position a little distance back of the posterior margin of the acetabulum; it is rather deeply lobed, two to four times on each margin. Its length is about 0.36 mm., and its greatest width and thickness about 0.23 mm.

A short oviduct leads from the ovary into the oötype (Fig. 10), and this former comes from the anterior middle of the ovary. From the oötype there arises Laurer's canal, which is a short duct leading to a dorsal pore at a level near the anterior margin of the ovary. Around the oötype is found Mehlis' gland, which is large and lies chiefly towards the ventral side. The oötype continues as the uterus, which characteristically passes forward to a level of the posterior margin of the acetabulum, then takes a sudden turn and runs posteriad along the right side to the posterior tip of the body. Here it forms a complicated coil and then passes anteriad up to the left side to join the prostate near the common genital pore. The uterus is filled with thin-shelled eggs, more or less pointed at one pole where there is a small lid. The eggs (Fig. 9) average 10 by 20 μ .

The vitellaria, or shell glands, are follicular, yellowish-brown structures lying along each side of the body from the posterior margin of the acetabulum to about midway of the posterior region of the body. Minute ducts gather up the secretion and the ducts from each side form a common duct at about the level of the ovary. The common ducts from each side pass into a little sac (Figs. 10, 17), about 8 μ in diameter, which lies just ventral to the ovary and has a minute duct leading into the posterior portion of the oötype.

The testes lie in the posterior portion of the body (Figs. 11, 18), both posterior to the ovary, altho in the oldest specimens the ovary may overlap the anterior portion of the testis. Both testes are ovoid, the posterior testis averaging 0.43 by 0.18 mm., and the anterior 0.49 by 0.17 mm. From the anterior margin of each and towards the dorsum, there pass forward the vasa efferentia. In the region of the ovary they pass in between its lobes. The testes and the seminal vesicle lie in the median line and into the latter the ducts from the testes pass. In older specimens the vesicle (Figs. 11, 16) is filled with spermatozoa, and these are divided into two regions, undoubtedly showing that the germinal products are all expelled at once from a given testis and that the two testes expel their products at different times. The vesicle is ovoid in shape and averages 0.39 by 0.17 mm. It is covered by a thin wall and from its anterior sinistral margin there passes the cirrus sac, crescentric in shape, containing unicellular prostatic glands and, anteriorly, the cirrus, which is extremely thick (Fig. 21). This duct joins the uterus immediately before the genital pore and anterior to it.

LIFE HISTORY

As soon as the infection of the buffalo fry was noted an examination of snails was undertaken, and many of the following species from several ponds were inspected. These represent all the different species found in any great numbers around the ponds: *Lymnaea obtusa*

exigua Lea, *Succinea retusa* Lea, *Planorbis trivolvis* Say, and *Physa heterostropha*. Of these four species none were found to be infected save certain individuals of *Planorbis trivolvis*, and these from ponds in which there were adult infected buffalo fish. The following table shows the number examined from pond 7 D where the infection was about 10%.

	Number Examined	Number Infected
July 23.....	5	1
24.....	5	0
25.....	4	1
27.....	3	1
31.....	67	5
Aug. 3.....	36	4
Total	120	12

These snails had cercariae (Fig. 3) infecting their livers, and in the water of an aquarium in which these infected snails were kept these cercariae were found swimming about in great numbers.

No counts were made, but it was evident that the entire livers of the snails were filled with this cercaria, and that there were perhaps several thousands in each host. The cercariae were very active and moved about very rapidly. There seemed to be a tendency for them to throw off their tails, and they were often seen in that condition when they became sluggish.

The tail (Fig. 25) of the cercaria is not quite so long as the body, and in the illustration (Fig. 3), which was made from life with the cercaria moderately extended, the tail was 0.27 mm. long. It is not perfectly smooth, but here and there shows indentations. The body of the worm is oval elongate and rounded anteriorly; the length and width vary with the degree of contraction, but in the illustration is 0.40 mm. long and 0.14 mm. wide in the acetabular region. The whole body is covered with spines and the two very prominent suckers are surrounded with them.

The oral sucker (Fig. 22) is about 72μ wide and has a very small stylet (Fig. 8) set into its anterior margin. This interesting organ is in the shape of a pen point and 18μ long and 4μ wide at the base. About one third of the length from the anterior end there is a thickened expansion. The ventral sucker lies two thirds of the distance from the anterior tip of the body and is about the same size as the oral, but more nearly circular in shape as seen from the ventral or dorsal surface.

The stylet glands (Figs. 3, 23) lie anterior to the acetabulum and are in right and left sets. In each set are from four to six fairly large cells that have ducts leading antieriad to open near the base of the stylet. Cystogenous gland cells are numerous over the body and are found chiefly posteriorly.

The digestive tract is already well developed and has a small pharynx, esophagus and diverticula. These latter do not reach to the end of the body and in most cases do not extend below the acetabulum.

The excretory system is well developed (Fig. 3). There is a bicornuate bladder some distance from the anterior end of the tail, from which two divisions pass anteriad. A short distance from the bladder they each give off a large branch which passes posteriad, and these in turn divide into anterior and posterior ducts. The remainder of the main divisions pass anteriad giving off branches until near the level of the oral sucker they turn back on themselves and pass posteriad, ending near the middle of the body. A branch passes from the bladder posteriad and has the excretory pore on it at the posterior end of the body. Then a branch passes out into the tail from this pore as a median caudal duct. Excretory granules were not noted in the tubules.

Nothing of the nervous and reproductive systems could be made out in the living material, but in preserved material one could see a small group of cells just posterior to the acetabulum, the first trace of the ovary (Fig. 24). No indication of the male genital system was noted.

In certain snails, apparently those which had not been very long infected, there were found non-motile sacs (Fig. 7) which contained the developing cercariae, and in some instances the cercariae themselves. One sac, 1.3 mm. long and 0.23 mm. wide and bluntly rounded at both ends, was found from which all the cercariae had escaped save one. Another sporocyst which contained no fully developed cercariae was 0.71 mm. long and 0.12 mm. wide. In this the germ balls were ovoid in shape and the largest ones were 0.10 by 0.05 mm.; there were about fifty such germ balls.

Three attempts were made to infect buffalo fish directly with the cercariae. The method was to make a suspension of cercariae in water and to inject the fish with it. In the case of the experiments with fry the cercariae were placed in an aquarium with a little water and the fry allowed to remain in this for several hours; controls showed that they would eat the cercariae or at least take them in with water. The first attempt was made on July 23, when four buffalo fish from the river were injected. The next attempt was made on July 27, when three one-year-olds from pond 7 *D* and three adults from the river were injected, and the final trial was made on July 31, when twelve fry from pond 4 *D* were fed cercariae. Controls were kept and the fish were killed at varying periods of time. In all the experiments no indication of experimental infection was noted. None of the river fish were infected, and the few infected pond fish had infections of such long standing that it was impossible to consider them as being experimental.

Indeed, controls killed a few hours after being injected showed clearly that the cercariae were being digested, and that this digestion was going on in the stomach. The evident conclusion was that the normal infection is not direct and a secondary intermediate host was sought.

In previous studies it has been shown that the forms of plankton which figure most in the food of the buffalo fish are Chydorus, Daphnia, Cyclops, Diaptomus, Diffugia, Bosmina, rotifers and chironomid larvae. The cercariae were larger than any one of these forms, with the exception of the largest rotifers and chironomids, but for experimental control reasons they were placed in a watch glass with these plankton forms and allowed to remain together for several hours. At the end of the time examinations were made of many individuals of the different species and of these, the cercariae had not attacked any save the chironomid larvae. Every one of the larvae in the dish had just beneath the skin from one to seven cercariae encysted (Fig. 4) in spherical cysts. A few days later this experiment was repeated, and this time the cercariae were seen to attack the larvae actively, and by the use of their suckers and powerful movements of the tail they bored their way into the larvae. The stylet was evidently used in the process and the lashing of the tail served to spin the cercaria in much the same manner that an auger is used. The time required for the process averaged about twenty minutes. Several species of chironomids were tested and no preference was noted. The only species identified were *Chironomus lobiferus* Say and *Tanytus decoloratus* Malloch, but other species of larvae were observed to become infected. The cercariae dropped their tails before they had completely entered their host, and when they had entered discharged their cystogenous substance, rolled themselves into a ball, and remained just beneath the skin of the larvae, showing very little motion in the cyst. The stylet remained in place. After several hours excretory granules were seen to accumulate in the posterior part of the cercaria, and after twenty-four hours quite a portion of the posterior excretory tube was filled.

Two series of experiments were undertaken to infect buffalo fish with the infected chironomid larvae. The first of these was begun on July 31. The livers of three infected snails were teased out in a little normal saline and added to an aquarium containing many thousands of chironomid larvae. These were allowed to remain from 11 a. m. to 3:30 p. m., at which time they were examined, and it was noted that nearly all of the larvae had encysted cercariae in them. Twelve buffalo fry and three yearlings were then put into the aquarium. At 5 p. m. one fry was examined; it had not eaten chironomids and was uninfected. Twenty hours after feeding, another fry was examined, and this one had eaten several larvae, which were partly digested. In the intestine of this fish were four cysts containing cercariae, which were

very active and contained a large mass of excretory granules (Fig. 5). Under the microscope one of the cercariae burst its cyst, expelled its granules and its stylet and assumed the shape and appearance of the definitive form. One partly digested chironomid still had a cyst in it. On August 1 three fry were examined and one yearling; the yearling had two young trematodes in its intestine, which were like in every respect the young trematodes taken from the fry which were infected in pond 3 F. The three fry had not eaten the larvae and were not infected. The rest of the fish were examined on August 2, only one fry being infected, and this one had still the remains of the chironomids in the lower part of the intestine. One or two of the other fish had eaten the larvae, but perhaps had not gotten hold of the infected ones.

On August 3 the experiment was repeated on six fry from pond 4 D where the fry were not infected, and four yearlings from pond 7 D. This time less water was used in the aquarium in which the fish were fed, and they were allowed to remain longer with the infected chironomids. Three fry and two yearlings were used as controls, and these were uninfected at the end of the experiment. Four out of the six fry were experimentally infected and three out of the four yearlings. In this lot various stages were found, from the still intact cysts to worms as large and larger than those found in natural conditions. One yearling examined on August 11 had three trematodes which gave the following measurements: (a) 0.80 by 0.30 mm., (b) 0.90 by 0.30 mm., (c) 1.41 by 0.41 mm.

Figure 6 shows one of these worms drawn from life, and in this the excretory system is identical with that of adult worms and is but a further development of the condition in the cercaria. The ratio of the size of the suckers, shape of the body, spinous skin and general movements of the body are alike in the young forms, adults, and cercariae. The immature forms obtained from the experimentally infected fish are exactly like those found in natural infections, their organ systems being carefully compared. In the development of the reproductive organs the ovary appears first, the two testes next, and the seminal vesicle last, altho the latter seems to be well developed as soon as the testes are ripe.

Attempts have been made to hatch the eggs from adult worms and thus to infect the snails with the miracidium, but so far none of the eggs have hatched.

In the light of the above experiments and observations an explanation might be offered as to why the river fish are not infected. *Planorbis trivolvis* is a very common snail around the ponds at Fairport, but does not seem to be found in the river near this station. The author has looked for it to some extent and so have others with negative results. This species of snail is common in some rivers, and no

MAGATH—LISSORCHIS FAIRPORTI

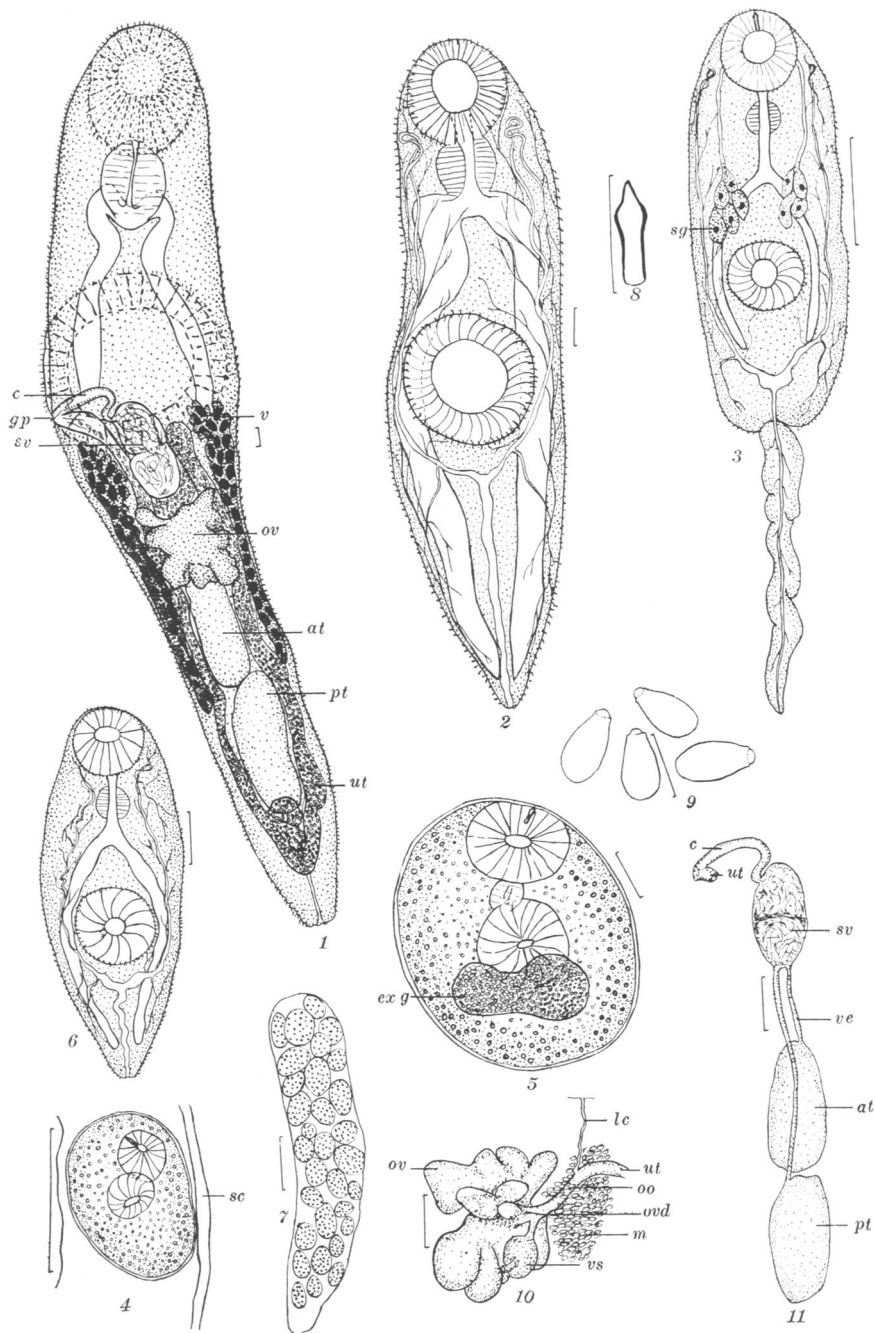


PLATE I

MAGATH-LISSORCHIS FAIRPORTI

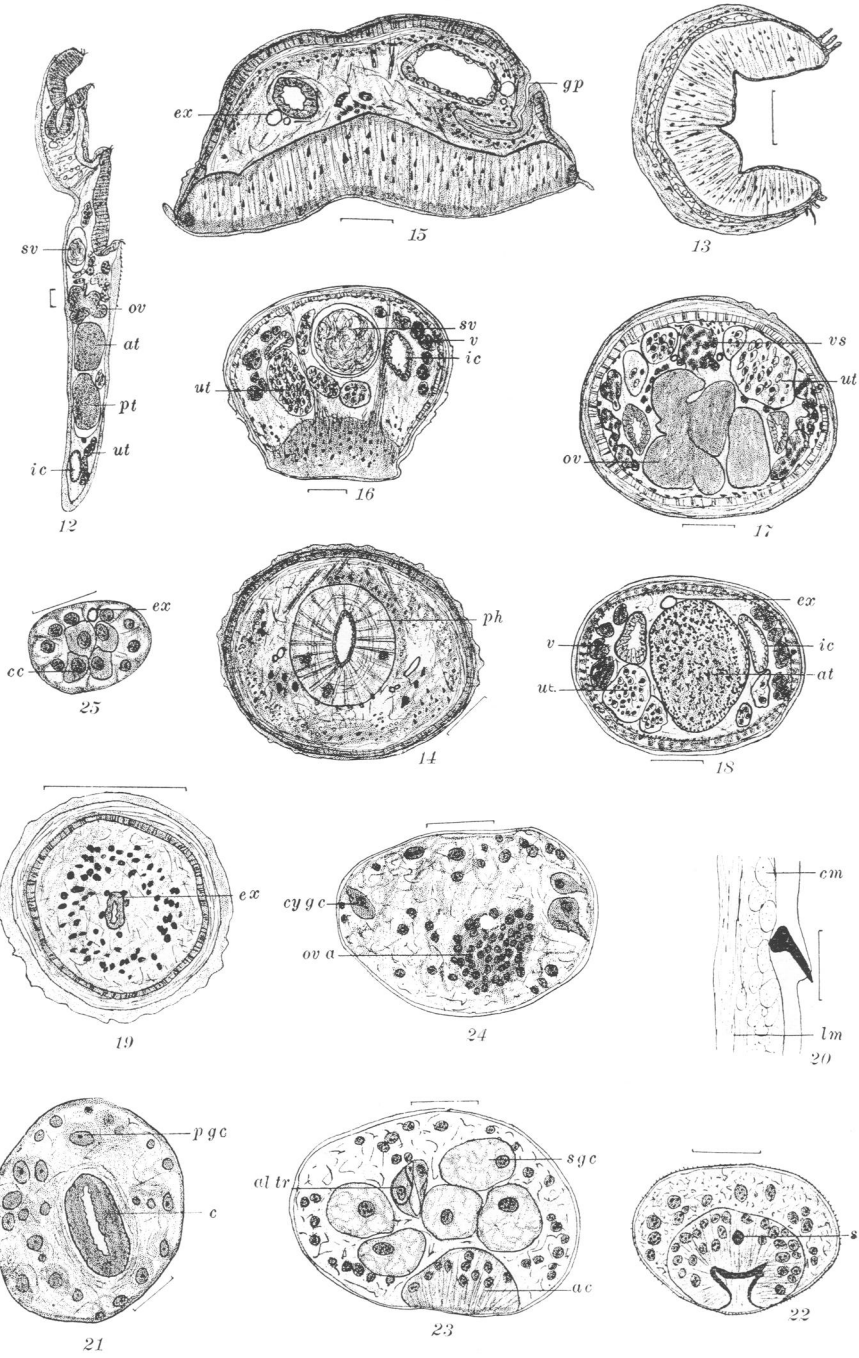


PLATE II

explanation can be offered as to why it is not found around Fairport. While some species of cercaria are known to occur in several snails, this is not always the case, and there is no evidence so far that the cercaria of *Lissorchis fairporti* occurs in any other snail.

It seems desirable to keep young buffalo fish free from this infection and the means of doing it is not so difficult as it might appear. The problem is obviously involved in keeping the fish pond free from this species of snail, and fortunately *P. trivolvis* carries its eggs on its back, so that if a screen which would keep out the snails themselves were provided around the pond and over the inlet pipe of the water supply, there would be no danger of the eggs being brought in, and as a rule there does not seem to be a very marked migration of these snails. Of course, the free cercariae or encysted cercariae might be brought in with the water, but the cercariae do not live very long outside of a host, and this fact would favor prevention of infection. It appears from the evidence at hand that after the fish have grown past three or four inches long they are fairly safe, and hence they would not have to be protected for more than a year. The author has started some experiments along this line and also on the effect of the parasite on the buffalo fry which he hopes to bring to a definite end in the near future.

In the examination of infected fish it was noted as the summer advanced that the average size of the trematodes in the fish was greater than at the beginning of the summer, that more eggs accumulated in the uteri of the worms, and that toward the last of the summer they began to expel them in great numbers. In the early summer there were more sporocysts found in the livers of snails than in the later summer, which is correlated with the previous statement as might be expected. From these observations and the experimental evidence, it seems likely that the miracidium hatches out from eggs laid in the late summer and finds its host, the snail, before the winter sets in; that it develops in the liver of the snail during the winter and spring, and in the first part of the summer the cercaria leave their hosts. The infection of the chironomids and fish naturally takes place during the later part of the summer. It is barely possible that some of the first to infect the fish mature before fall, but it is more likely that they all live over winter in the fish before they become mature. The facts that the eggs are in the last stages of cleavage in the late summer and the infection of the snails is so far advanced by early summer, support the conclusion that the miracidium is hatched in the fall and lives over winter in the snail.

The lower percentage of infection in pond 2 *F* is explained by the fewer chironomids in the pond and the smaller percentage found in the food bulk of the fry in this pond than in the case of the fish in pond 3 *F*.

SUMMARY

1. An adult trematode, found in the intestine of *Ictiobus cyprinella* and *Ictiobus bubulus* from experimental ponds at the United States Bureau of Fisheries Biological Station at Fairport, Iowa, is shown to be a new species, *Lissorchis fairporti*, type of a new genus and new subfamily. About 50 per cent. of these fish are infected.

2. This parasite appears to be responsible for the large death rate in young buffalo fish in these ponds. It is not found in fish of the same species taken from the Mississippi River near Fairport.

3. The cercaria of this form has been found in *Planorbis trivolvis* and described; it belongs to the xiphidiocercariae. It encysts in chironomid larvae after boring thru their skin, and when these were fed to buffalo fish the worm was freed from the cyst and developed to stages like those found in nature in infected fish. Eggs from the adult trematodes probably hatch in the late fall and live over winter in the liver of *Planorbis trivolvis*. In the summer the cercariae find their way to water, infect chironomid larvae and in turn the fish. The absence of this snail from the river in the region of Fairport undoubtedly explains the lack of infection in the buffalo from that source.

4. Buffalo fish cannot be infected directly by feeding or injecting the cercariae into their stomachs.

5. Protecting the ponds in which young buffalo fish fry are being raised from *Planorbis trivolvis* would without doubt lower the infection among the fish.

The author wishes to express his thanks to Prof. Henry B. Ward for suggestions in regard to this manuscript.

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ABBREVIATIONS USED IN THE PLATES

<i>altr</i> esophagus	<i>ova</i> embryonic ovary
<i>at</i> anterior testis	<i>ovd</i> oviduct
<i>c</i> cirrus	<i>pgc</i> prostate gland cells
<i>cc</i> central cells of cercaria tail	<i>ph</i> pharynx
<i>cm</i> circular muscles	<i>pt</i> posterior testis
<i>cygc</i> cystogenous gland cells	<i>s</i> stylet
<i>ex</i> excretory canal	<i>sc</i> skin of chironomid larva
<i>exg</i> excretory granules	<i>sg</i> stylet gland
<i>gp</i> genital pore	<i>sgc</i> stylet gland cell
<i>ic</i> intestinal crura	<i>sv</i> seminal vesicle
<i>lc</i> Laurer's canal	<i>ut</i> uterus
<i>lm</i> longitudinal muscles	<i>v</i> vitellaria
<i>m</i> Mehlis' gland	<i>ve</i> vas efferentia
<i>oö</i> oötype	<i>vs</i> vitellarial sac
<i>ov</i> ovary	

PLATE I

Fig. 1.—Dorsal view of *Lissorchis fairporti*, showing genital systems. The spinous condition of the integument should be noted.

Fig. 2.—Ventral view drawn from life, showing the details of the excretory system.

Fig. 3.—Cercaria drawn from life as seen from the ventral side, showing alimentary canal, stylet glands and excretory systems.

Fig. 4.—Encysted cercaria in a chironomid larva. Drawn from life.

Fig. 5.—Encysted cercaria, freed from a chironomid by the action of digestive fluids and found in a buffalo fry's intestine twenty hours after feeding infected chironomids. Drawn from life.

Fig. 6.—Young trematode from a buffalo fish experimentally infected three days before examination. Note excretory system and further development of the digestive system.

Fig. 7.—Sporocyst containing developing germ balls. From the liver of *Planorbis trivolvis*.

Fig. 8.—Stylet of cercaria.

Fig. 9.—Eggs of *Lissorchis fairporti*.

Fig. 10.—Reconstruction of the main parts of the female genital system drawn from a lateral view.

Fig. 11.—Reconstruction of the male reproductive system drawn from a dorsal view.

PLATE II

Fig. 12.—Sagittal section thru the midline of an adult, showing the relation of organs.

Fig. 13.—Cross section thru the oral sucker. Note the fleshy spines around the margin of the sucker.

Fig. 14.—Cross section thru the pharynx.

Fig. 15.—Cross section thru the ventral sucker at the level of the genital pore.

Fig. 16.—Cross section thru the seminal vesicle.

Fig. 17.—Cross section thru the ovary at the level of the vitellarial sac.

Fig. 18.—Cross section thru the anterior testis.

Fig. 19.—Cross section thru the posterior region of the body, showing the median stem of the excretory canal.

Fig. 20.—Details of the body wall showing spine.

Fig. 21.—Details of the cirrus, showing unicellular prostate glands.

Fig. 22.—Cross section thru the oral sucker of a cercaria.

Fig. 23.—Cross section thru the anterior region of the acetabulum showing the stylet glands.

Fig. 24.—Cross section thru the embryonic ovary of a cercaria.

Fig. 25.—Cross section thru the tail of a cercaria. Note the central cells.

The individual scale drawn by each figure indicates 0.1 mm. in all figures except that it is 0.02 mm. long in Figures 5, 8, 9, and 20 to 25 inclusive.